

TRIGGER AND PHYSICS WEEK

and

MENUS FOR EARLY RUNNING WITH BEAM

**Building on discussions in PESA Algorithms
and Performance meetings, in Trigger and
Physics weeks, in TDAQ week, and in ad-hoc
TDAQ menus group**

Trigger and Physics Week (1)

■ Outline agenda is available:

- ◆ <http://indico.cern.ch/conferenceDisplay.py?confId=6824>
- ◆ Monday pm – opening plenary
- ◆ Tuesday am to Thursday am – parallel sessions
 - Combined performance and trigger slices WGs
 - Physics WGs
 - Data Preparation **NEW!**
- ◆ Thursday pm – closing plenary
- ◆ (Friday am – workshop on luminosity task-force follow up)

■ Main guidelines for issues to address

- ◆ 10^{31} Menu
- ◆ Express Stream
- ◆ Trigger-aware analyses
- ◆ Analysis Model: i.e. what do people use (AAN?, AODs?, slimmed AODs?)

Trigger and Physics Week (2)

- **Opening plenary (Monday pm)**
 - ◆ Introduction, goals of the week (15')
 - ◆ Status of SW, production, validation (20'+5')
 - ◆ Data Quality (25'+5')
 - ◆ Status of Luminosity TF recommendations (25'+5')
 - ◆ Report of the Metadata TF (20'+5')
 - ◆ Summary of the Analysis Model WS (20'+5')
- **Closing plenary (Thursday am)**
 - ◆ $L=10^{31}$ trigger menu (20'+5')
 - ◆ Express Stream (15'+5')
 - ◆ Status of Data Streaming Test (15'+5')
 - ◆ ATLFAST Phase 2 (20'+5')
 - ◆ G4-based Shower Parametrizations (20'+5')
 - ◆ Summary of Trigger sessions and next steps (20'+5')
 - ◆ Summary of Data Preparation session and next steps (20'+5')
 - ◆ Summary of Combined Performance sessions and next steps (20'+5')
 - ◆ Summary of Physics sessions and next steps (20'+5')
 - ◆ Final discussion, goals for next T&P week : 20'

Next Steps on Menu

- Aim to get concrete example of trigger menu for discussion at the next Trigger and Physics week (30 Oct – 2 Nov)
 - ◆ Need distributions of rates, not just tables
 - Be able to answer the question “what happens if you change the cuts or threshold?”
 - ◆ Need to think about how to use pre-scaled triggers and/or dedicated runs for specific studies (e.g. minimum-bias data)
 - For now developed model where data are collected concurrently
- Priorities in the next few months
 - ◆ Consolidate work on menu for $\sqrt{s} = 14$ TeV, $L = 10^{31} \text{cm}^{-2}\text{s}^{-1}$
 - In parallel, make a limited study for $\sqrt{s} = 0.9$ TeV, $L = 10^{29} \text{cm}^{-2}\text{s}^{-1}$
 - ◆ Later on will look at $L = 10^{32} \text{cm}^{-2}\text{s}^{-1}$ and above
 - Note that, although we are concentrating for now on low-luminosity running, we have to be careful that our algorithms are robust against pileup.
 - Also need to look at misaligned, miscalibrated detector

Notes for “brainstorming” at TDAQ week

- Worked together on a menu for running at $L = 10^{31} \text{cm}^{-2}\text{s}^{-1}$
 - ◆ Signatures (muon, electron / photon, ...)
 - ◆ Thresholds (LVL1, HLT – not yet separated LVL2 and EF)
 - ◆ Other settings (isolation, use of calo/muon/ID in HLT, etc)
 - ◆ Use of forced-accepts or HLT “pass-through”, etc
 - ◆ Rates
 - ◆ Coverage
 - For physics studies
 - Including control samples
 - With “insurance policy” of making sure that priority physics is covered with loose LVL1 selection (e.g. no isolation) and, initially, with HLT pass-through
 - Complemented with much lower thresholds for other physics, relying on the HLT to get the rate down
 - Also including pre-scaled LVL1 triggers for cross-checks
 - For detector studies
 - Samples for calibration and alignment
 - For trigger studies
 - Samples for measuring rates and efficiencies
 - » Needed to optimize trigger for future running
 - ◆ Recognize that menu will evolve with time
 - Initially LVL1 only?
 - Progressively increase reliance on HLT

LVL1 selection

- Can use very loose requirements and low thresholds for running a $L = 10^{31} \text{cm}^{-2}\text{s}^{-1}$ in Summer 2008
 - ◆ DAQ/HLT should be able to handle >45 kHz by then (provided funding agencies pay their share of cost-to-completion, etc)
 - In general, LVL1 will not be the limiting ingredient
- Thresholds and rates need to be checked (and corrected) by people working on the different slices
 - ◆ Inclusive muon selection with lowest threshold that can be programmed – limitation is the connectivity of the trigger system
 - Threshold ~ 5 or 6 GeV (perhaps lower in end-cap)
 - Rate less than ~ 1 kHz – can use relaxed coincidence requirements
 - ◆ Inclusive EM cluster trigger with low threshold (limited by rate) and no isolation requirement
 - Threshold ~ 10 GeV for rate ~ 10 kHz (to be checked)
 - ◆ Investigate two-EM cluster trigger for $J/\psi \rightarrow ee$ selection
 - How low a threshold can we get for acceptable rate (~ 10 kHz?)
 - Around 2EM5? (to be checked)
 - ◆ Plus inclusive non-isolated tau/hadron trigger with higher threshold
 - Provides cross-check since it is inclusive of EM selection for the corresponding threshold
 - However, are we really worried that electron/photon showers will not be contained in the EM calorimeter?

LVL1 selection

- **Thresholds continued**
 - ◆ **Inclusive isolated tau/hadron**
 - **Threshold about 10 GeV for rate ~ 5 kHz**
 - **Interesting for tau physics studies and also for hadronic calorimeter calibration**
 - ◆ **Considerable bandwidth could be given to jet and missing ET triggers, but this is only useful if the valid events can be kept in the HLT**
 - **Use prescales and multiplicity requirements to allow measurements from minimum bias to highest pT**
 - **Additional prescaling in HLT will allow us to collect uniform statistics over large pT range**
 - **Collect samples for tuning b-jet tagging algorithms, etc**
 - ◆ **Random BC trigger provides zero-bias sample at LVL1**
 - **Rate ~ 160 Hz at LVL1 would give 10 Hz of non-empty events**
 - ◆ **Inclusive selections listed above cover many compound triggers**
 - **Nevertheless, it is interesting for LVL1 to flag events that pass triggers such as muon-electron**

Example: HLT selection for muons

- LVL1 inclusive trigger with threshold $\sim 5\text{-}6$ GeV
 - ◆ Gives rate ~ 240 Hz
- Suggested HLT selection:
 - ◆ MU15 (no isolation requirement) forced accept: ~ 50 Hz
 - Insurance policy for high-pT physics
 - ◆ MU6 (no isolation required), pre-scale 10, forced accept: ~ 24 Hz
 - Insurance policy
 - Tune muon HLT
 - ◆ Mu6 (no isolation required), normal HLT selection: ~ 80 Hz
 - B-physics
 - Tune B-physics triggers
 - Detector alignment (muon, ID)
 - Detector calibration (e.g. Tiles)
 - ◆ Note that rates should not be simply added up since there is significant overlap between these selections

Example: HLT selection for electrons

- LVL1 inclusive EM with threshold ~ 10 GeV (no isolation)
 - ◆ Gives rate ~ 10 kHz
- Suggested HLT selection for electrons:
 - ◆ Selection without using HLT (initially):
 - EM30 (no isolation) ~ 60 Hz
 - Insurance policy for key physics – isolation requires good understanding of trigger and detector performance
 - EM25i (with isolation) ~ 60 Hz
 - EM20, 15, ... with increasing pre-scale factors
 - ◆ Selection using HLT allows much lower thresholds
 - e10i? – threshold limited by HLT output rate
 - e15i? – threshold limited by HLT output rate
 - ◆ Two-cluster trigger with much lower thresholds
 - 2EM with HLT forced accept
 - Even lower threshold using HLT to select 2e or 2g

Triggers for the 900 GeV run

- The following is a draft text that I have prepared for a note that is being written on the objectives for the 900 GeV run that is scheduled for late 2007
 - ◆ I have highlighted the main points
- The trigger for running with proton--proton collisions at $\sqrt{s} = 900 \text{ GeV}$ and the assumed luminosity of $10^{29} \text{ cm}^{-2}\text{s}^{-1}$ will be based on a combination of a pre-scaled minimum-bias selection, and the muon and calorimeter LVL1 triggers with very low pT thresholds.

LVL1 trigger using MBTS

- For an estimated inelastic, non-diffractive cross-section of 40 mb, the **interaction rate will be 4 kHz**, very well within the design capability for input to the LVL2 trigger system if an effective minimum-bias selection can be made at LVL1. This could be provided using the **Minimum-Bias Trigger Scintillators** (MBTS) and associated logic to provide an input to the Central Trigger Processor. However, it should be noted that the **signal-to-noise** ratio of the MBTS signals that are available to LVL1 is **modest**, and that some bias may be introduced by this selection.

LVL1 random BC trigger

- It is interesting to include, **in addition** to the above, a LVL1 trigger based on random bunch crossings. Assuming **43 bunch-crossings per 88 microsecond** LHC orbit in the initial running considered here, the **bunch-crossing frequency** will be about **500 kHz**. Hence, close to **1% of bunch crossings** selected at random by the LVL1 trigger will **contain an interaction**. For illustration, LVL1 could **select one bunch crossing in a hundred** (using either a prescale or a pseudorandom number generator, both of which are included in the CTP). This would give a rate of **5 kHz** of bunch crossings, most of which would be empty. **Further selection** could then be performed **at LVL2**, rejecting the empty events, while introducing as little bias as possible. **Some fraction** of the random bunch-crossing LVL1 triggers should be recorded **without HLT selection** for technical studies and to give a sample **completely free of any trigger bias**.

HLT selection for minimum bias

- Various techniques are being studied for the minimum-bias LVL2 selection. One approach is to use the **precision readout of the MBTS** which has a much **better signal-to-noise** ratio than is available at LVL1. Another approach is to use **inner-detector information**, possibly just counting hits (e.g. in the pixel detector), possibly reconstructing tracks in a full-scan. Forward detectors such as **LUCID** could also be used **if available**. Several techniques could be used in a logical-OR to minimize the biases and to allow cross-checks. After the LVL2 selection the rate should be dominated by bunch-crossings containing a proton--proton collision. Hence the rate would be about 40 Hz for the prescale factor of 100 in the illustration.

LVL2 full scan?

- **An interesting possibility that is being investigated is to operate a full-scan inner-detector algorithm at LVL2 on the minimum-bias events from LVL1. In addition to refining the minimum-bias selection --- for example by making a very loose requirement on the presence of tracks coming from the interaction region --- one could in principle make a selection on high-pT tracks. Such events could be very useful for technical studies such as optimizing b-jet tagging algorithms. However, it should be noted that one cannot rely on such a complicated HLT algorithm being available for online selection during the short 900 GeV run, the first time the trigger will see real collision data.**

LVL1 muon trigger

- The LVL1 muon trigger can be used to obtain a sample of events containing muons with **pT larger than about 5--6 GeV** (perhaps somewhat lower in the forward region). This is the lowest threshold that can be set, **limited by the cabling** between the different stations of the trigger system as well as by the muon energy losses in the calorimeters and the magnetic bending in the toroids that prevent low-pT muons from reaching the outer stations. **The rate is expected to be small, at the level of a few Hz, and no further selection should be required from the High-Level Trigger (HLT).**
- Given the very low rates expected for the muon trigger, some or all of the data could be taken with **relaxed LVL1 conditions**. For example, one might select muons using only the phi projection in the trigger chambers, and/or use a relaxed condition on the number of hits per track.
- The acceptance and efficiency combined are about 80% for muons with $pT > 6 \text{ GeV}$ and $\text{abs}(\eta) < 2.4$.

LVL1 calorimeter trigger

- **The LVL1 calorimeter trigger could be used to select events with reasonably high- p_T jets, hadrons, electrons/photons and large missing or total transverse energy. It can also be used to identify the regions of interest in events that are selected by the LVL1 MBTS trigger --- the LVL2 trigger, if commissioned at that stage, could then be used to make a cleaner and more refined selection than would be possible using LVL1 alone. In both cases, the thresholds should be set as low as possible consistent with the rate capability of the HLT and keeping above the level at which detector noise dominates the rate.**

LVL1 calorimeter trigger (2)

- A very rough estimate is that LVL1 could be used, without further selection in the HLT, for an inclusive **jet selection** with a threshold of about **25 GeV**, and an inclusive **electron/photon** trigger with a threshold of around **10 GeV** (isolation not required). Here the efficiency is typically 90-95% for jets/particles with pT at the threshold value, increasing at higher pT, within the pseudo-rapidity acceptance of the trigger. It is worth noting that the LVL1 **jet threshold curve is not very sharp** and there will be reasonable efficiency for jets with pT above about 15 GeV.
- A **comprehensive LVL1 calorimeter-trigger menu** should be implemented, including items such as an inclusive missing-ET and sum-ET trigger that may be dominated by instrumental backgrounds; these can be prescaled down to an acceptably low rate. The corresponding samples will be **extremely valuable for commissioning studies for the trigger, detectors and possibly also the machine.**

Running triggers in flagging mode

- Although it appears that it will **not always be necessary to use the HLT** actively to select events during the initial 900 GeV run, the full system should be operated in flagging mode as part of the commissioning exercise. This will **allow trigger performance studies to be performed offline** using the recorded data that include the results of the LVL1 and HLT processing.
- Similar **considerations apply to the LVL1** muon and calorimeter triggers. Here one should include a full trigger menu, even if some of the items (such as isolated electrons or jets with high p_T thresholds) will be redundant.

Summary of LVL1 rates

- In summary, with the assumptions described above, the output of LVL1 would be about **4 kHz of minimum-bias** interactions selected using the MBTS (not prescaled), **plus 5 kHz of random bunch-crossings** (about 1% containing a fully unbiased sample of interactions, the rest being empty bunch crossings) --- this rate could be increased by adjusting the prescale factor if HLT bandwidth is available. The events selected by the calorimeter trigger and muon trigger would largely overlap with those from the MBTS trigger; in any case their rates will be modest.

Summary of HLT rates

- Following the HLT selection, the **total minimum-bias rate could be prescaled to about 50--100 Hz**. This could be shared between: (a) events selected using the LVL1 MBTS selection (prescaled); (b) those from the LVL1 random bunch-crossing trigger with HLT selection; and (c) a prescaled sample of events from the LVL1 random bunch-crossing trigger without HLT selection. The motivation is to record data that will be insensitive to problems with the LVL1 and HLT systems that will, at the time of the 900 GeV run, not be fully commissioned.

Selection of high-pT objects

- **It is suggested not to use the HLT actively in the selection of muons, jets and electrons/photons. The short 900 GeV run should rather be used with the HLT in flagging mode. This will provide valuable experience in operating the system and large data samples that can be used, offline, to test and optimize the LVL2 and EF algorithms prior to the first 14 TeV data taking.**